ON THE CAUSE OF THE HOLES THAT OCCUR PERFORATING SHEETS OF MELTING ICE.

PRIZE ESSAY

IN

THE CHEMICAL CLASS,

MARISCHAL COLLEGE, ABERDEEN,

Session 1837–8.

BY

JOHN FERGUSON OF NIGG,

STUDENT OF MEDICINE.

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ON THE CAUSE OF THE HOLES THAT OCCUR PERFORATING SHEETS OF MELTING ICE.

The holes in question are generally about one or two inches, and sometimes more, in diameter. In shape, they are more or less round, but seldom completely cylindrical. In direction, they are most commonly perpendicular to the surface of the ice. After a thaw, they may be readily seen in the sheets of melting ice that float down a river, or on the sea-shore near its mouth. They occur not only in very thin sheets of ice, but in ice upwards of three inches in thickness, and not only in ice disintegrated by melting into a porous texture, but in ice apparently the most compact.

In order to ascertain the cause of these holes, the structure of ice was first considered. Depressions, especially in the under surface of ice, may be observed, and, at such depressions, it may be supposed that the ice will melt into holes; and this in fact happens. But the holes thus formed are seen only in ice less than half an inch in thickness, they are bounded by thin sharp edges, and they are seldom round, so that they do not at all resemble those that are the object of the present inquiry.

Air cells, which are to be found in all ice, varying greatly in their size and frequency in different pieces, but in both respects very equally distributed in the same piece, may also produce small holes in very thin ice; but these are easily distinguished from the larger holes in question, which, as has already been mentioned, occur in ice, although thick, and whether porous or compact.

Ice, in freezing, has a tendency to assume a crystalline structure, which, were it to differ in any one part from the rest, might, in such part, occasion a corresponding facility in the melting. Yet no such difference was detected by inspecting newly frozen ice; and pure newly-frozen ice was observed to melt by a warmer atmosphere, or by the sun, without forming any of the holes in question. Ice, indeed, while melting, sometimes appears to consist of a number of prisms laid loosely in apposition, and directed perpendicularly to the plane of the sheet. But I could never succeed in driving any one of these prisms through into a hole, without, at the same time, breaking the surrounding ice. Besides, the holes to be explained are not peculiar to ice of such structure.

As none of the circumstances attending the formation of ice seemed to account for the appearance of the holes in question, attention was next given to ice during the process of melting. After the formation of ice, indeed, and while hard frost continued, nothing rudimental of a hole could ever be observed. Thus the question came to be, What circumstance in the melting gave rise to the holes?

Their frequent occurrence in ice at the mouths of rivers might suggest the idea of their being dependent on salt water —a conjecture supported by the well-known effect of salt in lowering the freezing point of water, and its consequent power of melting ice. The holes, however, occur in inland pools, and in rivers at a distance of several miles from the sea. I froze sea-water by exposing it during a very cold night to radiation—the natural freezing agent. When the ice thus produced was melted, in almost every natural manner, none of the holes were formed, but only a spongy porous texture, in consequence of the rapid melting apart of almost all the ice impregnated with saline substances. I also immersed common ice in sea-water, where the melting took place more rapidly than in fresh of the same temperature; but, in other respects, little, if any, difference of action was observed. From these and similar considerations, I inferred that the formation of the round holes is little dependent on the presence of saline substances in considerable quantity—much less in the exceedingly minute quantities held in solution in ordinary fresh water.

The remarkable property of becoming specifically heavier, as it ascends in temperature from 32° F. to 38° F. belongs to water. On account of this property, water lying in a depression on the surface of a sheet of melting ice, would obviously undergo a circulation, the portion heated by the air descending in the centre, and, when cooled by ice at the bottom, rising by the sides. The immediate consequence of the warmer water being thus always conveyed to the bottom, would be to melt the ice at that part, and thus produce a hole. But when a depression was made in a sheet of ice, and water put into it, the depression, so far as I could observe, continued of the same depth during the whole time of melting. Hence, in such circumstances, the ice probably received the heat as fast as the water.

After having thus far failed to account for the appearance in question, I made an observation that indicated what seems to be the real cause.

In the course of my observations on ice melting on the sides of rivers, I frequently saw holes not entirely perforated through the ice. In the bottoms of these, I always observed solid bodies—stones, dust, sand, bark of trees, or the like. In one instance, of which I had taken particular notice, I subsequently observed that the imperfect hole had been rendered complete, and corresponded in size to those, the cause of whose formation I had been attempting to discover. I then placed a stone above a piece of ice during sunshine, and examined it on the following day, when a complete hole, bigger than the stone, was found in the ice below the place where it had rested. I confirmed these observations by experiments repeated under varied circumstances, always with like results. Thus, having placed upon ice almost all such small bodies as are usually found on the sides of rivers, I exposed it, in order to melt, both in the rays of the sun and in a warm atmosphere. In all the experiments, holes were produced. I have also seen, where two sheets of melting ice were lying, one above the other, a complete hole through the upper, and an incomplete one through the under sheet, continuing the upper hole, and having at the bottom a bit of clay. Under the same circumstances of temperature, holes were produced when the bodies were put below the ice, so as to allow it to rest on them, and, when dust, crumbs of brown wood, and other such light substances, were placed below, they rose up, by capillary attraction, as the holes upwards approached the surface, always keeping the top of it, till the holes were completed. After exposure for one or two days, the holes produced in my experiments, as also those whose formation I had watched, were, by continued melting, ultimately smoothed into the same appearance as those for whose origin I had been seeking to account.

The principle on which these foreign bodies act in producing holes, is their possessing the property of absorbing radiated heat in a higher degree than ice. That this explanation may be applicable to cases in which the body has sunk so far into the ice as to be out of the reach of the direct rays of the sun, or has been originally below the ice, it is necessary that ice should give passage to the heat of the sun's rays. That ice has this property, was determined experimentally. I took a sheet of pretty-transparent newly frozen ice, fully half an inch thick, and having smoothed the inequalities of its surfaces, I found that I could inflame a piece of sealing-wax, by concentrating on it the rays of the sun, by means of a burning-glass, whether the ice was interposed between the sun and the lens, or between the lens and the wax. The effect, indeed, seemed to be little diminished by the interposition of the ice. Yet, that ice does not transmit heat altogether without interruption, appeared from the possibility of melting a hole in the most transparent ice by the same lens. Hence it appears that heat, radiated from the sun, will pass through ice with little interruption to any opaque foreign body, by which it will be absorbed, and by which it will be communicated, by conduction, to the contiguous ice.

The sun is evidently not the only source of the radiated heat absorbable by such foreign body. Thus, we can scarcely suppose that all the sun's heat is intercepted by the clouds, even in a day the most overcast, as such a circumstance never happens with his light ; and, when ice is melting in a warm room, not only the fire, but the walls and furniture, are sources of radiant heat. The natural exposure appeared to be most favourable to the formation of the holes ; for, in the rays of the sun, a sheet of ice, with a stone above it, was often entirely perforated, before the sheet had melted a quarter of its thickness, while, in a warm room, it would first have to melt nearly half its thickness. Perhaps the reason was, in part, the more equal action of heat derived from the atmosphere by conduction, and, partly, the greater absorption by the ice of heat radiated from terrestrial objects, than of heat emanating from the sun.

The explanation of the form of the holes will now be easily understood. As the bodies that produce them, generally either, are of themselves round or oval, like most of the small stones found on a river-side, or are collected by the washing of the water into circular heaps, as in the case of sand, it is evident that the holes must, from the first, tend to assume a circular form. But, as an additional widening of the hole, during and after its formation, always takes place, owing to the continued melting of the ice, the first irregularities become ultimately less observable. The holes are seldom of equal width throughout, being sometimes wider above than below, at other times the reverse. The foreign body that forms the hole has originally descended, when the hole is wider above—the first formed part of the hole being widened by its longer subjection to the common melting that the whole sheet undergoes—and, in the reverse case, the body has been below the ice, and has ascended.

I have never observed any of the holes, not completely perforating the ice, without having at its bottom some opaque foreign body. The holes, during their formation, take a direction perpendicular to the horizon; and the occasional obliquity of the holes, in reference to the surface of the ice, is to be accounted for, by their having been formed when the sheets lay in a position oblique to the horizon.

Before the breaking up of ice by a thaw, the holes most usually are to be observed at the sides of rivers. Indeed, I have scarce ever seen them in the middle. After the breaking up of ice by a thaw, several circumstances serve to increase the number of holes. On the sides of rivers, there is generally a collection of small round stones. Upon these, sheets of ice, when floated up by the rise of the tide, are left, and, during the thaw, soon become perforated with holes upwards. If such holes should not be complete at the time, they are rendered so by subsequent melting. As the stones, in such situations, frequently rise an inch above the surrounding level, they may perforate holes in ice an inch thick. The holes in ice of greater thickness, are commonly produced by bodies lying above the ice, such as the small stones that are washed upon the ice by the agitation of the water, or bits of bark, or of brown wood. Such light bodies, when they float, sometimes produce holes upwards, by being placed below the ice. Holes break out, also, wherever light bodies have been frozen into ice, as occurs in almost every situation. Collections of sand, earth, or clay, constitute another very usual cause of holes.

Standing waters afford peculiar occasions for foreign solids to produce holes in its ice. In a pool, where small single blades of grass had been frozen into ice of two or three inches thickness, I have observed that, during a thaw, the ice immediately surrounding the grass melted into a round hole, often an inch or two wide; and, in ice upwards of three inches thick, where a few withered rushes—one here, one there—were frozen, in a horizontal position, in the middle of the ice, every rush, after a few days' thaw, had a space around it, large enough to hold ten rushes. The vital heat of the grass may have contributed to the melting; but the dead rushes could only have acted like any other opaque inorganic solid.

Holes of a similar origin to those in ice, accounted for in this Essay, occur also in melting snow, where dust, or other opaque solid, has lain on the surface.

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CHEMICAL CLASS, MARISCHAL COLLEGE.

SESSION 1837–38.

COMPETITION EXERCISE.

Questions to be answered in Writing, without the aid of any Note, written or printed.

1.—Describe how to procure the Oxide of Antimony pure—specifying the precautions.

2.—Describe how to ascertain the strength of pure dilute Nitric Acid.

3.—Describe and explain the process, as practised in this country, for making Cast Iron.

4.—How is the Chlorate of Potash procured, and how the Oxychlorate?

5.—What is the action of Ammonia on Oxalic Vinous Ether? Employ diagram, symbols, and atomic weights.

6.—What is the usual process for manufacturing Carbonate of Soda?

7.—What is the composition of the Red Prussiate of Potash, and how may it be procured?

8.—What is the manufacturer's process for procuring Iodine?

9.—What is the action of the waterless Sulphuric Acid on Chloride of Potassium?—what the effect at different temperatures?—and give the probable explanation.

For best performing the above Exercise, Prizes were awarded to—

John Ferguson, Nigg,
John William Trail, A.M., Udny,
Thomas Halliday Young, Lockerby, Dumfriesshire.